Understanding and Protecting Our Home Planet

NASA's Earth Science Enterprise

Our Planetary Thermostat…

Venus

Carbon cycle

Loss of carbon -- no lithosphere motion to release carbon

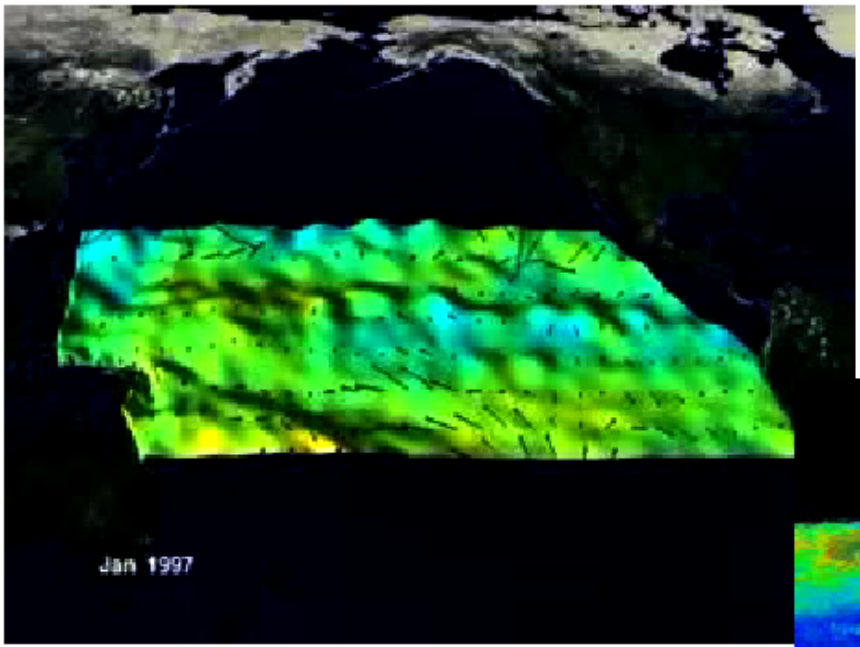
Runaway greenhouse effect -- no water cycle to remove carbon from the atmosphere

Water cycle

Mars

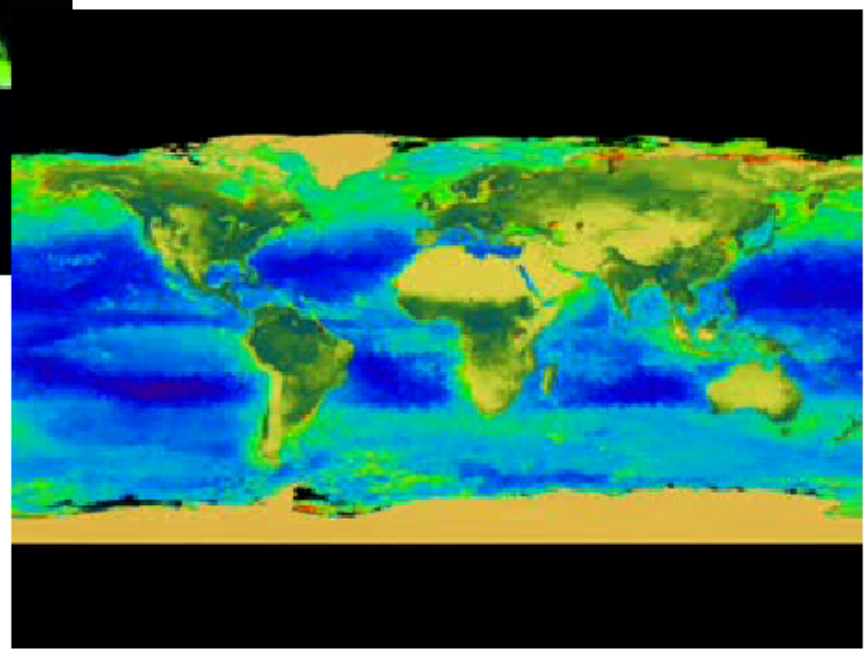
…has maintained a stable climate for millions of years

Over Shorter Time Periods, However…



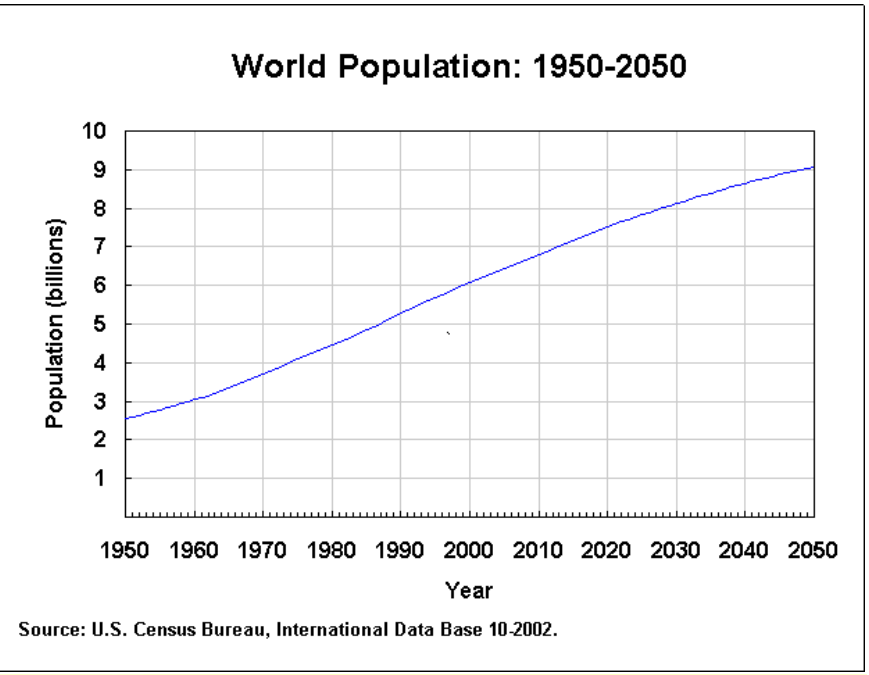
1997-99 El Nino / La Nina

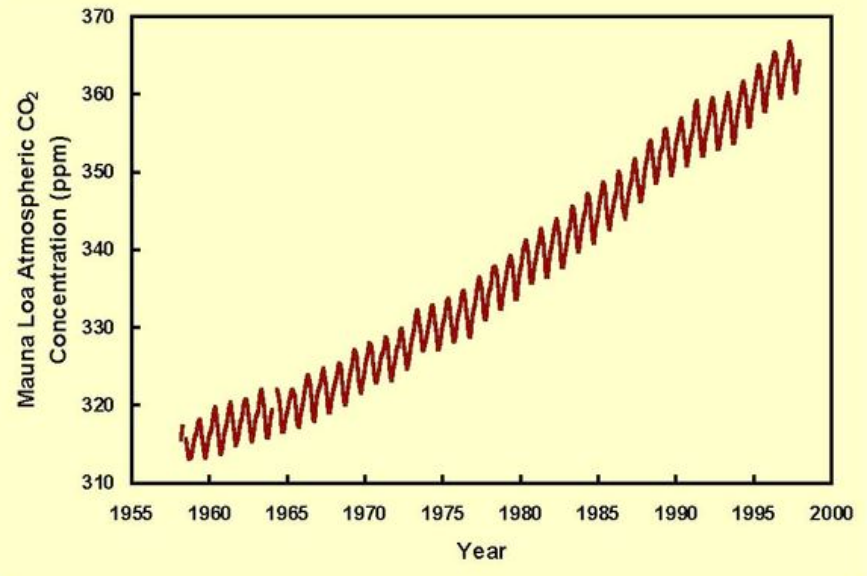
Seasonal Biosphere 1997-2000 from SeaWiFS

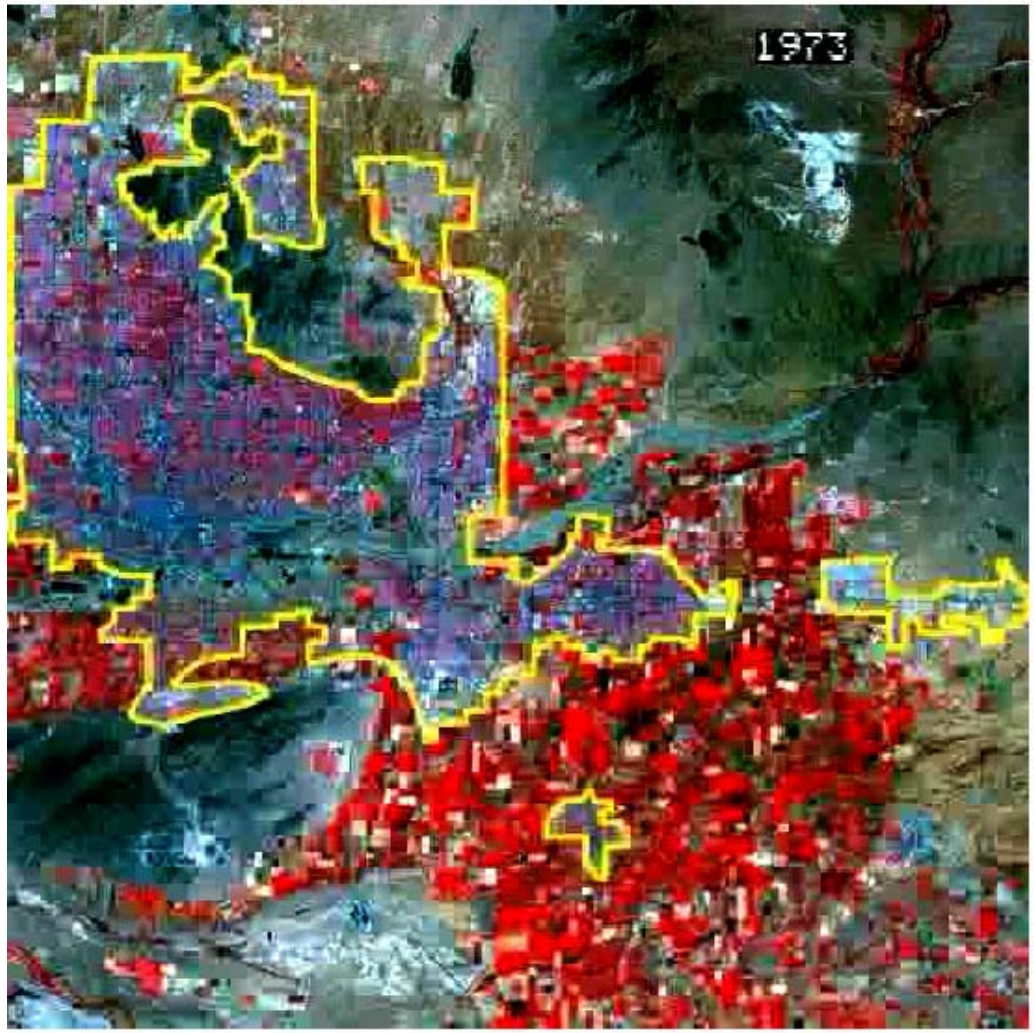


…climate has exhibited considerable natural variability

Recently the Impacts of Human Activity Have Become More Apparent







The Challenge of Earth System Science

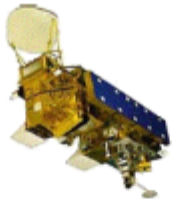
- Describing the interactions among Earth's continents, oceans, atmosphere, ice, and life
- Making global observations at 'scales that matter', i.e., at regionally discerning resolutions
- Accurately representing these interactions & ingesting these observations into coupled Earth system models
- Creating processes of prediction and assessment in forms useful to decision-makers


The NASA Vision
To improve life here,
To extend life to there,
To find life beyond.
The NASA Mission
To understand and protect our home planet,
To explore the universe and search for life,
To inspire the next generation of explorers
... as only NASA can.

NASA's Earth Observing System & Related Satellites

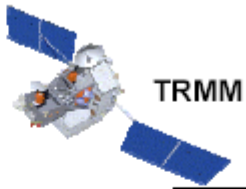
The Earth Observing System -- systematic measurement of interactions among land, oceans, atmosphere, ice & life

Landsat



Aqua

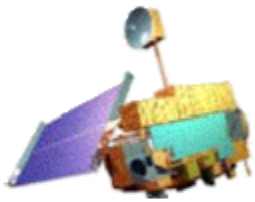
Exploratory missions to probe key Earth system processes globally for the first time



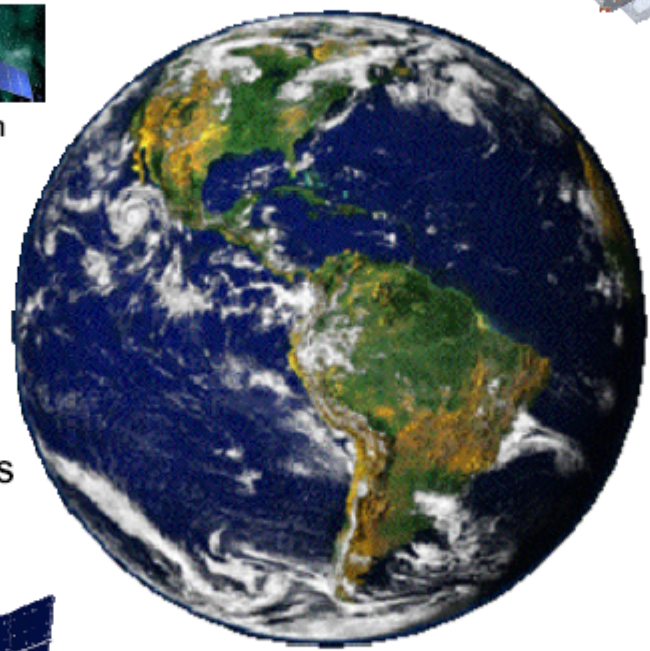
TRMM

GRACE

Jason

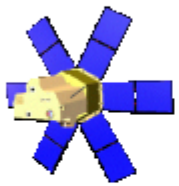


Terra

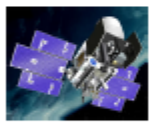


Calipso

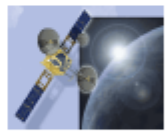
Cloudsat



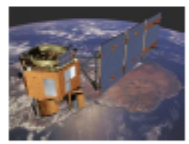
SORCE



ICESat



EO-3: GIFTS

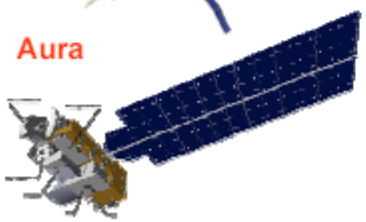


EO-1: ALI & Hyperion

SeaWiFS

Operational precursor / Technology demos

Aura



NOAA/ GOES

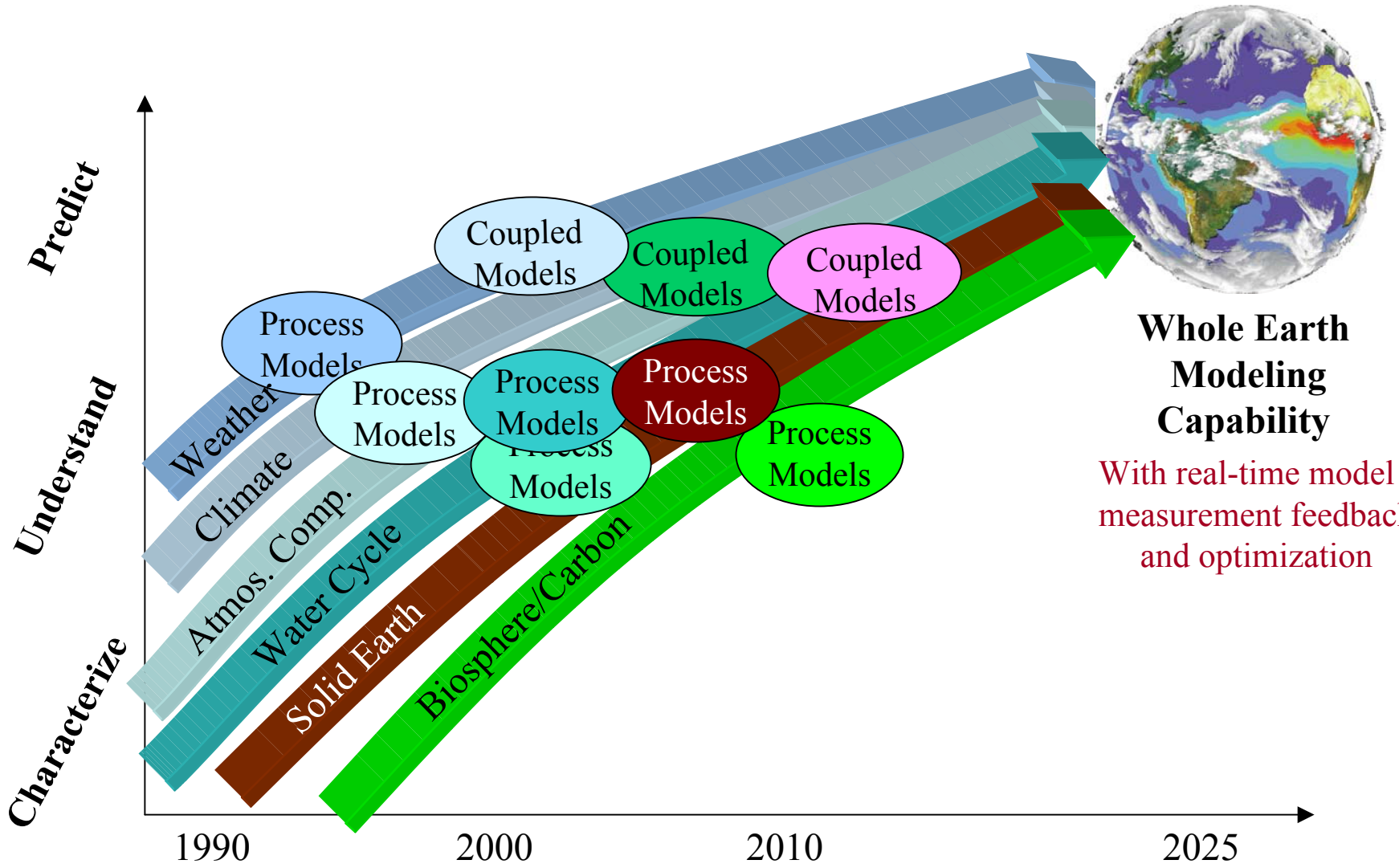
Operational weather services missions for NOAA

NOAA/ POES

Evolution of Earth System Science at NASA

- **1960s to 1980s: Exploring the Possibilities**
  - Birth and early development of satellite remote sensing
  - Technology demonstration was the driver
- **1990 to 2000: Surveying the Earth System**
  - Birth and evolution of the Earth System Science concept
  - Focus on providing a broad suite of observations to observe, document and understand Earth system change
- **2000 to 2020: Focus on National Needs**
  - Answer high-priority science questions with profound national/international economic and policy relevance
  - End-to-end science, technology & applications approach
- **2020 and Beyond: Enabling Ubiquitous Use of the View From Space**
  - Information delivery from space to decision-makers' desktops in a timely and affordable manner

Earth System Science



Managing the End-to-End Information Flow

Petabytes 10^{15}

Multi-platform, multi-parameter, high spatial and temporal resolution, remote & in-situ sensing

Calibration, Transformation To Characterized Geophysical Parameters

Terabytes 10^{12}

Interaction Between Modeling/Forecasting and Observation Systems

Gigabytes 10^{9}

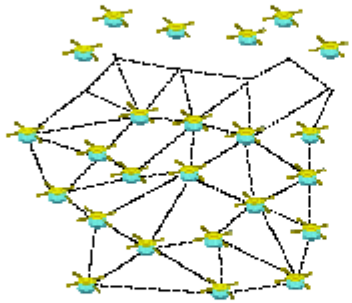
Interactive Dissemination

Predictions

Megabytes 10^{6}

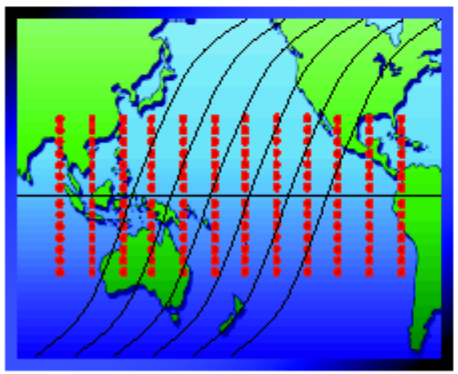
Advanced Sensors

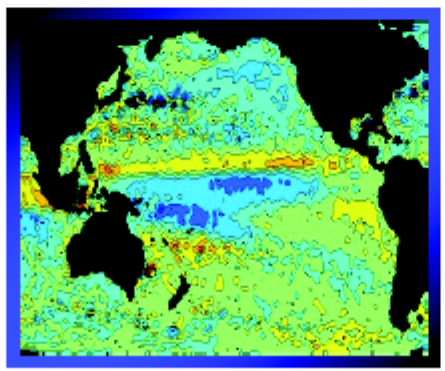
Data Processing & Analysis

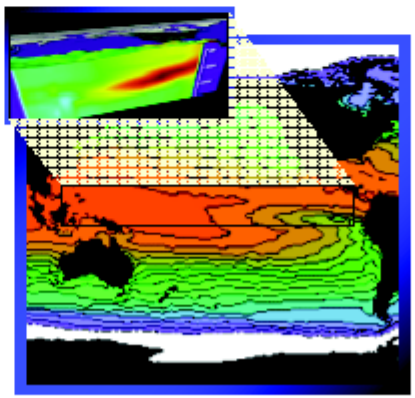


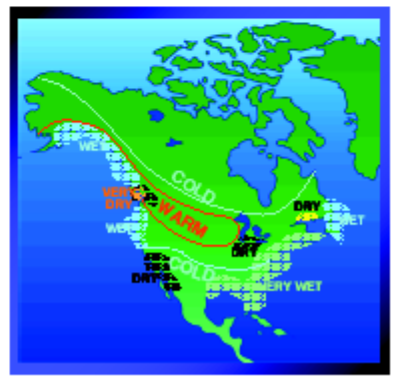
Information Synthesis

Access to Knowledge





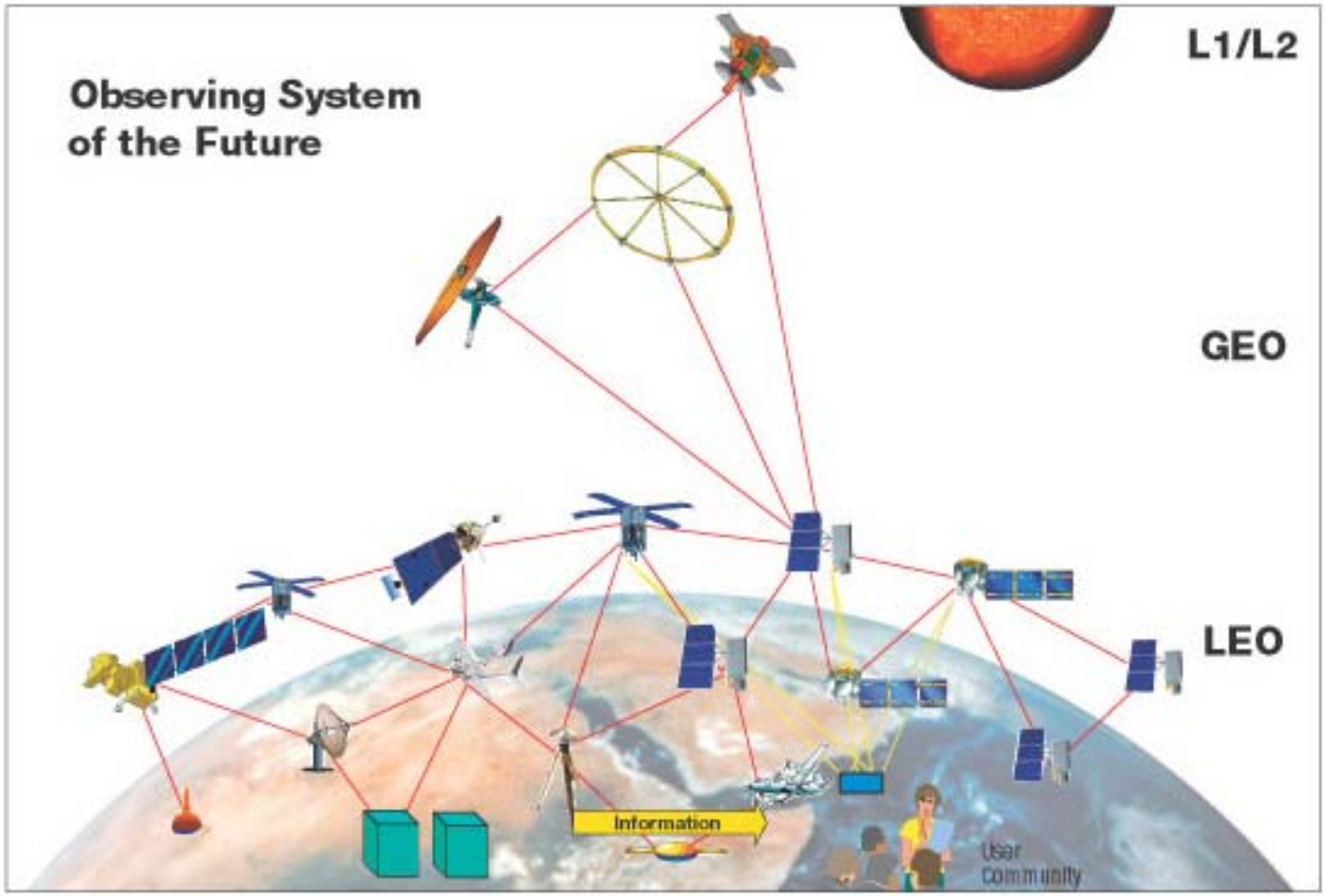




Approach to the Future

- Emphasize information synthesis and knowledge delivery
  - Pursue technologies for communications and computational modeling as well as observation
- Design flexibility into observing & information architectures
  - Standards and protocols to enable "plug compatible" contributions from diverse partners
  - Enable integration of space-based, suborbital, and *in situ* observing systems
- Build partnerships around common goals rather than overlapping requirements

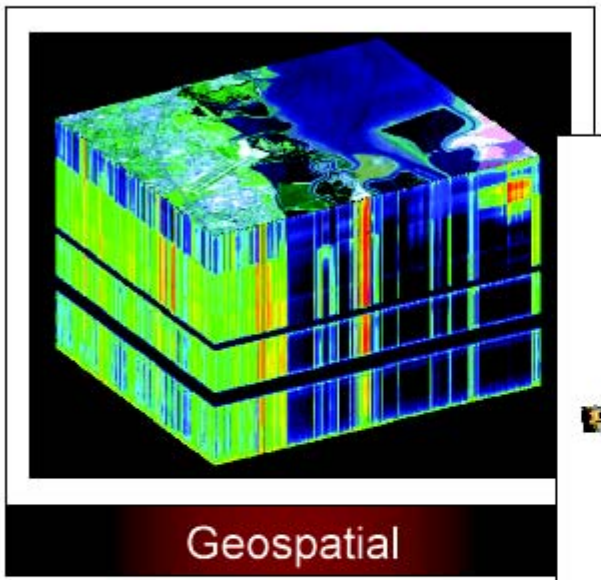
An Integrated Global Observing System

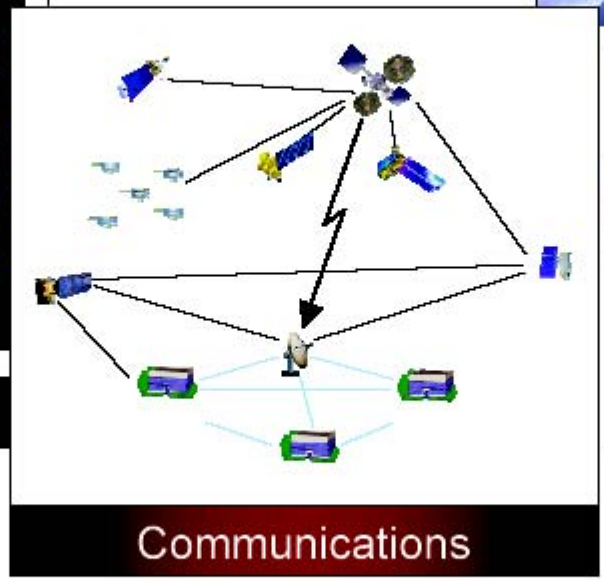


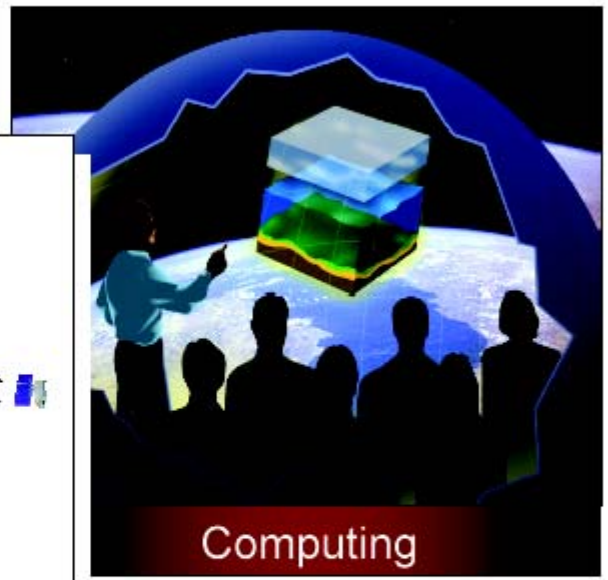
Multiple vantage points, multiple partners

Technology Emphasis Areas

Earth System Science in the future will leverage three ongoing technology revolutions:



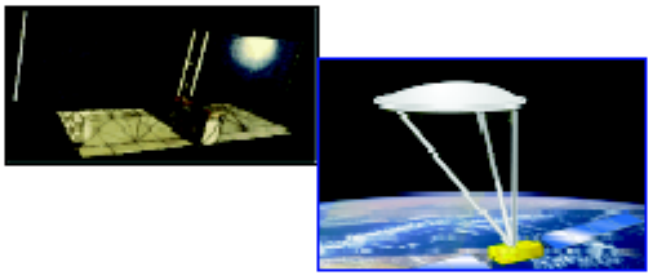




...To enable timely and affordable delivery of Earth Science data and information to users

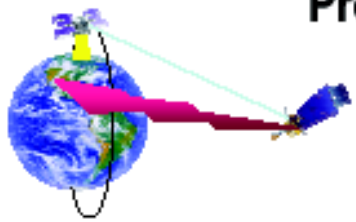
High-Priority, Key Technology Validation Needs for Earth Science

Large Deployable Antennas

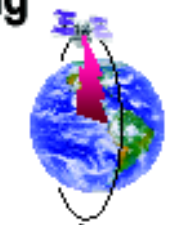


Validation enables improved soil moisture and global precipitation science capabilities

Communications & On-Board Processing



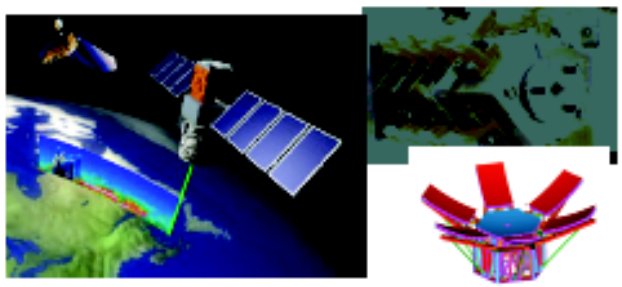
Optical Comm from LEO to GEO



RF Comm demonstrates Ka-band in space

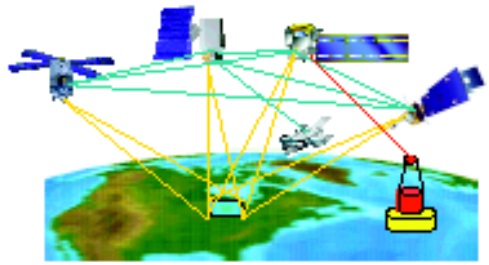
Technology significantly improves spatial/spectral resolution and temporal coverage for science missions

Lasers and Deployable Telescopes



Flight validations enable atmospheric chemistry, aerosols and winds science missions

Distributed Platforms



Distributed platforms will lead to "sensor webs" for ocean and atmospheric science missions.

Challenges Ahead

- Understanding the Earth system with sufficient depth to enable a predictive capability useful to society at large
- Stewardship of vast quantities of data and information now becoming available
- Simultaneously generating long-term climate data records and making new measurements with new technologies to explore little-understood Earth system processes
- Generating knowledge products useful to non-Earth science specialists in their own decision-making processes

Challenges Ahead

- Advancing computational modeling capacity
  - 100x to advance from global to regional (human) scales
  - 1000x to incorporate chemical and biological processes
  - 10000x to run a complete Earth system model suite capturing all the major interactions among continents, oceans, atmosphere, ice, and life that ultimately shape the climate system
- Designing the global observing system of the future
- Training the next generation of Earth scientists, engineers and technologists

Understand and Protect

- **Earth System Science: Dr. Marshall Shepherd**
- **Earth Science Applications: Dr. Roger King**

From Science to Societal Impact (and Back)